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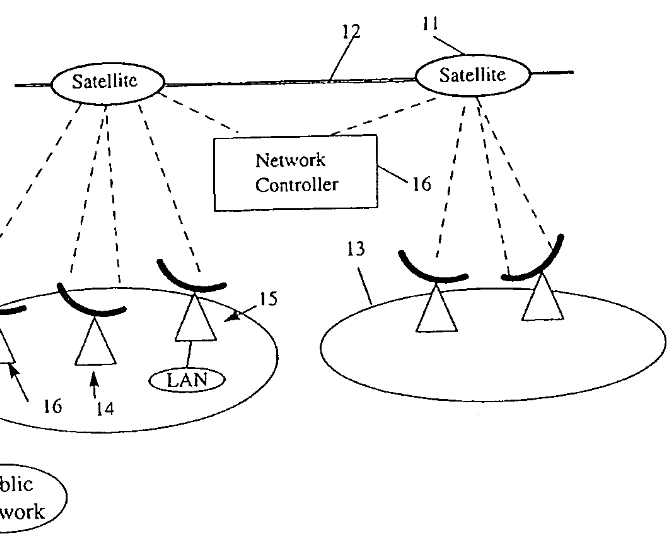

(57) Abstract

A packet communications network comprises a constellation of non–geostationary satellite nodes serving ground stations. The satellites are interconnected by inter–satellite links so as to define a mesh network in the sky. Routing of packet traffic at each satellite node is performed using a diversion algorithm which chooses links to adjacent satellites based on a destination address included in each packet. The packet is then routed on whichever of the selected links has available capacity. This minimises queuing of packet traffic in the satellite node. The maximum rate at which packets are transmitted from the ground stations to the satellites is limited so as to minimise queuing in the satellite and so reduce the need for buffering.

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CONNECTIONLESS SATELLITE NETWORK

This invention relates to a system and a method for routing broad band packet services in a connectionless network having a plurality of satellite nodes.

BACKGROUND OF THE INVENTION

Connectionless network operation has been traditionally used in data communications in order to achieve two objectives, firstly to allow client/server operation between endpoints of a network with all intelligence distributed to the endpoints and secondly to allow topological change within the network to occur without the network endpoints needing to be aware that a change has happened.

Networks based on the Internet Protocol (IP) are typical embodiments of these principles. Similar principles are embodied in Wireless and Satellite networks in order to avoid the need for explicit connection hand-overs due to the physical mobility of users or systems.

Satellite communications systems employing geostationary satellites carrying traffic between ground stations are well established. Although such systems are effective in operation, they suffer from two limitations. Firstly, a geostationary satellite occupies an equatorial orbit and thus its 'footprint' may not extend to higher latitudes. Secondly, a large number of geostationary satellites have already been installed and there are now very few orbital positions available for new satellites to provide further capacity. To address these problems, there have been recent proposals to provide satellite systems in which non-geostationary satellite nodes co-operate with a ground-based network to form a global communications system.

As an example, a method of providing communications in a system employing non-geostationary satellites is described in specification No US-A-5,621,415. In that arrangement, the satellite footprints are partitioned into linear spanning cells containing multiple linear segments to reduce the hand-off overhead. The physical network consists of moving satellites, each having a footprint corresponding at a given time to many cells. Each satellite is at least connected to its immediate neighbours in the four directions by ISL (inter-satellite-link). All the satellites are substantially identical yielding a super symmetrical network in the sky. An originating subscriber to the network sends communications packets on an up-link, i.e. a communication channel to the satellite that currently serves the spanning cell that houses the originating subscriber. This up-link is usually accessed through a multiple access protocol ruling the way the up-link is shared among the subscribers. The satellite then forwards the communications packets to adjacent satellites until they arrive at the satellite that covers the spanning cell housing the destination subscriber. The destination satellite then sends the packets on a down-link, i.e. a communication channel from the satellite that currently serves the spanning cell housing the destination subscriber. As the satellites move around their orbits, and as the Earth rotates, different satellites cover the spanning cells at different times. Non-geostationary satellite networks typically are designed so that for every time and for every cell there exists at least one satellite that covers the cell. As the footprint of a satellite stops covering a spanning cell, the satellite hands-over the responsibility of the cell to the satellite that covers the cell next.

Further satellite networks are described in our United Kingdom patent applications Nos 9707832.3, 9716333.1 and 9716331.5 which relate to methods of modelling satellite networks to determine the network topology.

Transport of broad band connection-less services over connectionless satellite network composed of a constellation of geostationary (GEO), Medium Earth Orbit (MEO) or Low Earth Orbit (LEO)

satellites is a major issue since, contrarily to their terrestrial counterpart, buffering, routing tables and processing are very limited in the satellite nodes and, in the case of non-geostationary systems, mobility of the satellites introduces a great deal of complexity and new issues. These services are connection-less in that they do not require a fixed amount of bandwidth at all time and their requirements in terms of Quality of Service (QoS) are low, in particular in that they are not delay sensitive. Examples of such services are IP services or, in an asynchronous transfer mode (ATM) context, unspecified bit rate (UBR) services. Services of this type are also referred to as best-effort services.

A particular problem with any network having satellite nodes is that of reducing the complexity of the equipment that each satellite must carry to perform its switching and routing function and to limit the amount of buffering resource that is needed to resolve output contention between packets wanting to access the same output link at the same time. It will be appreciated that additional complexity not only increases the cost of the satellite itself, but also increases the risk of in-service failure.

A further problem in such systems is that of queuing of packets awaiting routing at a satellite node. Packets arriving at a node are handled in order of their arrival and a routing decision is made for each individual packet. Under busy conditions, some of the outgoing communications from a satellite can become congested leading to further delay. Accommodation and management of long queues of packets in a satellite node requires a significant amount of memory and associated control equipment together with the necessary power supply, and this is inconsistent with the need to minimise both the cost and the weight of the satellite node. It will be appreciated that, even a small increase in the weight of a satellite results in a very significant increase in the cost of launching the satellite and installing it in the desired orbit.

SUMMARY OF THE INVENTION

An object of the invention is to minimise or to overcome the above disadvantages.

Another object of the invention is to provide an improved method of routing traffic in a satellite communications network.

A further object of the invention is to provide a means of routing broad band best-effort services within a connectionless satellite network composed of many satellites with on-board processor (OBP) facilities.

A further object of the invention is reduce the complexity of equipment to be provided in a satellite network node.

According to a first aspect of the invention, there is provided a method of routing packet communications traffic in a communications network comprising a plurality of ground stations coupled by respective communications links to a constellation of satellite nodes interconnected by inter-satellite links, the method including providing each packet with a destination address, and, at each said satellite, reading the address of a said packet and, in response thereto, determining a first preferred link and a second auxiliary link for routing the packet, to a selected adjacent satellite via a said inter-satellite link or to a ground station with which the satellite is currently associated, and routing the packet, either via the first link when that that link is currently available, or via the second link when the first link is currently unavailable.

According to another aspect of the invention, there is provided a communications network for carrying packet traffic in which each packet is provided with an address indicative of its destination, the network comprising a plurality of ground stations coupled by respective communications links to a constellation of satellite nodes interconnected by

inter-satellite links, wherein each said satellite has means for reading the address of a said packet and, in response thereto, for determining a first preferred link and a second auxiliary link for routing the packet, to a selected adjacent satellite via a said inter-satellite link or to a ground station with which the satellite is currently associated, and means for routing the packet, either via the first link when that that link is currently available, or via the second link when the first link is currently unavailable.

According to a further aspect of the invention there is provided a connectionless communications network for transporting packet communications traffic between user terminals, the network comprising;

a ground network portion consisting of a plurality of cells containing a plurality of said user terminals, gateways and concentrators referred to as ground stations; and

a satellite network portion consisting of a plurality of non-geostationary satellites, said satellites being interconnected by inter-satellite links so as to define a mesh network;

wherein, each said satellite has transceiver means for communicating selectively with said ground stations to transmit packets thereto and receive packets therefrom, and wherein each said satellite has address reading means for reading destination information contained in each said packet, and routing means responsive to the read address of the packet for directing that packet via a said inter-satellite link to an adjacent satellite or to a said ground station.

According to another aspect of the invention there is provided a communications satellite node for a connectionless communications packet network, the satellite node comprising transceiver means for communicating with a ground station to transmit packets thereto and to receive packets therefrom, address reading means for reading destination information contained in each said packet, and routing means responsive to the read

address of the packet for directing that packet via an inter-satellite link to an adjacent similar satellite or to said ground station.

According to another aspect of the invention there is provided a method of routing packet communications traffic in a satellite communications system in which satellite nodes communicate with ground stations and are coupled via inter-satellite communications links, the method comprising:

providing each said packet with a destination address

determining from said address whether a communications packet received at a said satellite node has a local destination corresponding to a ground station currently in communication with the satellite, and routing that packet to the ground station in response to such a determination;

determining, when a communications packet has a non-local destination, a first preferred and a second less preferred inter-satellite link to an adjacent satellite; and

determining a criterion for routing a said non-local communications packet on either said first or said second inter-satellite link.

According to a further aspect of the invention there is provided method of routing packet communications traffic in a satellite communications system in which satellite nodes communicate with ground stations and are coupled via inter-satellite communications links, the method comprising:

transmitting packets from one or more said ground stations to a said satellite node;

determining at the satellite node for each said packet an inter-satellite link on which to transmit that packet to an adjacent satellite, the packets to be transmitted on each said inter-satellite link being placed in a;

determining the magnitude of said queue; and

restricting the rate at which packets are transmitted from the one or more ground stations when the queue magnitude exceeds a predetermined value.

According to a further aspect of the invention, there is provided a communications satellite node for a network arranged to carry packet traffic in which each packet is provided with an address indicative of its destination, the satellite node having means for establishing a plurality of communications links, means for reading the address of a said packet and, in response thereto, for determining a first preferred link and a second auxiliary link for routing the packet, and means for routing the packet, either via the first link when that that link is currently available, or via the second link when the first link is currently unavailable.

The invention further relates to a method of routing best-effort services in any connection-less satellite network in a way that takes into account the constraints and limitations of switches in the sky and controls the offered traffic by controlling the up-link access so as to minimise the queuing of the offered traffic within the satellite node and thereby reduce the buffering requirements within the satellite.

The technique is applicable to any connectionless satellite network which is composed of a constellation of satellites linked by inter-satellite links where the satellites have on-board processor facilities and act as packet switches, relays or routers, and where up-links to the satellites are either dedicated to a ground station (for example a gateway) or shared among many users through some multiple access protocol. In the case of multiple access up-links, there is usually a central entity either ground or satellite based that allocates the up-link resources to the users based on an allocation protocol.

Advantageously, a deflection routing algorithm is employed in order to further minimise the need to buffer non-delay sensitive packets at the satellites where buffering is scarce and expensive to provide. Deflection algorithms have been proposed in the context of super-symmetrical whole-optical networks for which optical buffering is difficult to implement (and non optical buffering is too slow). Satellite networks share many of the characteristics of whole-optical networks in that they are super-symmetrical and buffering is scarce because of the cost of its provision in a satellite. However there are many differences between an optical network and a satellite network. In a non-geostationary satellite network, satellites are moving which increases a lot the complexity of the routing function, hence the need for simple and robust solutions. Further satellites cannot, without considerable expense, handle routing requiring heavy processing. Furthermore, contrarily to optical nodes, satellites have usually natural means of controlling their offered local traffic through the entity controlling the allocation of the up-link bandwidth. I have found that deflection algorithms are simple to implement in the satellite network and obviate the need to provide heavy processing for routing and huge buffering in the satellite node. Further, I have found that such algorithms perform well even when the network topology changes continuously.

In a preferred embodiment of the invention, the physical network is a super-symmetrical network that consists of moving or fixed nodes (i.e., satellites) having very limited buffer space. Routing is based on a deflection algorithm so that a packet that sees a large queue on its preferred inter-satellite link (ISL) will in general be deflected to another ISL with a smaller associated queue thus obviating the need for being buffered long to wait for its preferred ISL to become available. In this technique, if a preferred inter-satellite ink for a particular packet is congested, then the packet is launched on an alternative inter-satellite link. This ensures that the queued packets are dealt with quickly and that queuing within the satellite node is minimised. Although the use of diversion routing may involve some packets undergoing

one or more additional inter-satellite 'hops' in order to reach their destination, the associated delays in transmission have been found to be inconsequential. One of the main drawbacks of deflection algorithms is that the useful throughput (i.e., the 'goodput') tends to decrease if the offered load is too large. I have found however that an effective input control restricting the number of packets sent from a ground station to a satellite can be performed by the entity allocating the resources on the up-link from the ground station to the satellite. In this way, the offered load can be maintained below the point at which performance in terms of 'goodput' start degrading. By controlling the packet throughput in this way, the buffering requirements in the satellites can be significantly reduced. This represents a significant cost saving in both construction and installation.

BRIEF DESCRIPTION OF THE DRAWINGS

An exemplary embodiment of the invention will now be described with reference to the accompanying drawings in which:-

Figure 1 illustrates the super-symmetrical structure of the satellite network portion of the communications system;

Figure 2 illustrates the construction of the ground network and its association with the satellite network; and

Figure 3 is a schematic diagram illustrating the construction of a satellite node in the network of figure 1.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring first to figures 1 and 2, the network comprises an array of satellites 11 constituting the network nodes and interconnected by inter-satellite communications links (ISL) 12 between adjacent satellites. These

inter-satellite links will typically comprise microwave links carrying a number of communication channels. It will be understood that, as a consequence of the way in which the satellites move in their orbits relative to each other, some of the inter-satellite links may be established on a permanent or semi-permanent basis, while other inter-satellite links may be of a short term nature. The ground portion of the network is partitioned into a number of cells 13 each corresponding to the footprint of a satellite and each containing a plurality of ground stations, these ground stations being either user terminals 14 or concentrators 15 serving many subscriber stations or gateways 16 to public networks. The satellites 11 communicate with the ground stations via up-links and down-links, typically via microwave links, and provide the nodes of a communications network in which packet communications traffic is routed from ground station to ground station via one or more satellites. Operation of the system is controlled via one or more network controllers 16. Routing of each packet within the satellite network is determined from a destination address contained in a header forming part of the packet. It will be appreciated that although figure 1 depicts a regular array of satellites, this, in the case of non-geostationary satellite systems, is a highly idealised 'snapshot' view of the system as the satellites will be constantly in motion relative to the ground and to each other so that the network topology will be constantly changing. However, the satellite orbits and the corresponding topology changes are predictable in the short and medium term. In general, the prediction of the satellite motion and positions will be determined from a ground-based reference model which is updated from time to time from measurements of the satellite positions. Relevant parts of this prediction information can be transmitted from the control centre or network controller 16 to the satellites 11 so that each satellite is aware of its current neighbours and the inter-satellite links thereto, and is also aware of any impending hand over of a ground station to another satellite.

Typically, the satellites will be disposed in a plurality of polar orbits so as to provide effective global coverage.

Queuing of packets arriving from ground terminals at the satellite node and awaiting routing is minimised by controlling or restricting the rate at which the ground terminals can transmit these packets. This restriction can be applied via the network controller 16 which determines the allocation of channels on the up-link between the ground stations and the satellite. This channel allocation control may for example be on a TDMA basis.

A schematic diagram of the satellite construction is shown in figure 3. The satellite has a number of ports 21 through which inter-satellite link traffic is routed via respective transceivers 22. Each of the ports 21 incorporates a buffer 210 for queuing packets to be sent to an adjacent satellite over the respective inter-satellite link. The buffers 210 provide a queuing facility and are of very limited capacity. Because the rate at which packets are transmitted to the satellite is controlled by the network controller 16, and because the received packets are routed by a deflection algorithm which offers a choice of an alternative port where the preferred port is busy, there is no requirement to provide extensive on-board buffering of packets waiting to be processed. Two further ports 211 and 212 are used for respective up-link and down-link communication with the ground stations currently in communication with the satellite via transceivers 213. Operation of the satellite is controlled by a control circuit 23 incorporating a memory 25 in which information relating to the current and immediate future topology of the satellite neighbourhood is stored. This information can either be locally generated or can be received from the control centre and be periodically updated. The advantage of a routing based on deflection is that each individual satellite node does not need to have a complete view of the network, but needs to know only the positions of its immediate satellite neighbours. In a preferred arrangement, I employ a routing algorithm based on deflection for which the satellite will just need to know at any one time

the spatial direction (e.g. North, South, East or West) to which each ISL associated with that satellite is pointing. Routing of packets is determined from a packet address reader 26 and a router circuit 27 which selects first and second choice of ports determined from the packet address. A decision or ISL select circuit 28 associated with the router circuit then chooses one of the selected ports for transmission of the packet over the respective link depending on the status of the buffers and possibly other parameters such as priority. It will be appreciated that there is no requirement to provide the satellite with conventional complex and detailed routing tables as the satellite is not required to plan a detailed route for the packet throughout the network, but is required only to send that packet to an adjacent satellite on one of a number of possible routes. In effect, each packet finds its own way across the network to its destination.

The traffic level at which the restriction on packet transmission from the ground stations is applied may be determined from appropriate queuing theory. Preferably, however, this level is determined from feedback from the satellite based on the current fill level of its ISL buffers. As the buffers approach their capacity as determined via the satellite control circuit 23, a message is relayed to the network controller requesting that the restriction be applied to the ground stations currently in communication with the satellite.

In a preferred embodiment, the super-symmetrical satellite network comprises N substantially identical satellite nodes, each having j input inter-satellite links and j output inter-satellite links as well as an up-link and a down-link respectively from and to the ground stations currently within the footprint of the satellite. Depending on the system, the number of input and output inter-satellite links that are currently active (some may on occasion be temporarily disabled for reasons linked to the current satellite constellation topology) at any one time is the same. Each inter-satellite link

has a useful capacity C_i and the up-link and the down-link between the satellite and the ground station have each a total useful capacity of C_{ud}.

As discussed above, each packet has an header incorporating explicitly or implicitly the address of the destination. The header may also incorporate a priority indicator (P) and, if required, a 'hop counter' field allowing the counting of the number of inter-satellite links already traversed by that packet. Note that a deflection algorithm does not require the knowledge of the source address of the packet.

When a packet is received at a satellite, the address reader of that satellite first checks if the destination of the packet is local, i.e. the address corresponds to the ground station coverage currently associated with the satellite. If the destination is in fact local, the packet is directed to the down-link port for transmission to the ground station. There could be some provision for the case where the satellite knows that it is about to hand over the ground station region containing the destination of the packet to a neighbouring satellite, and evaluates that the down-link queue is too loaded for the packet to have a chance to be sent before the hand-over. In that case, the satellite may decide to send the packet towards the adjacent satellite for subsequent delivery to the ground station depending on the priority of the packet and the current value of the packet hop count in the packet header.

If the destination of the packet is not local, the satellite looks into its routing table to find the preferred inter-satellite link (ISL) and a second choice ISL for sending this packet towards its destination. Depending on the packet priority, the value of the hop counter and the occupancy of the buffer of the preferred ISL and the second choice ISL, a decision is taken about sending the packet in the buffer of its preferred ISL or deflecting it to its second choice (and possibly third choice).

The determination of preferred and auxiliary routes for a packet arriving at a node may, for example, be determined from the geographic direction of the destination relative to the current satellite position. Thus, if the ultimate destination of a packet is due east of the satellite, then an inter-satellite link in a generally easterly direction may be selected as the preferred link, and one or more other links in a generally north easterly or south easterly direction may be chosen as the reserve options in the event that the preferred link is not available. In this way, packets will be routed in directions generally towards their destinations even though there may be some deviation from the shortest path.

As an example of packet routing, consider a packet received at satellite 11a and having as a destination one of the ground stations currently associated with satellite 11b. The precise route between these satellite nodes is not critical as long as the packet is routed on links in the northerly (upwards) and easterly (right) directions. The satellite 11a can thus choose as its first choice and second choice routes for the packet the links 12N and 12E. As the packet is passed from one satellite to the next, each satellite receiving the packet determines the appropriate first and second choice links for onward transmission to the next satellite. This process continues until the packet arrives at the satellite currently in direct communication with the ground station to which the packet is addressed. The address is recognised by that satellite as being local and the packet is routed over the down link to the ground station.

The use of this diversion routing technique ensures that packets are processed rapidly and that local congestion is minimised so as to reduce queuing and to make efficient use of the system capacity.

Note that because the satellites are moving, there may on occasion be the possibility of bouncing back a packet that has been received on a given ISL on the same ISL. This will not in general present a problem as

the packet will still ultimately reach its destination via subsequent routing decisions. If necessary however, the packet hop counter can be used to identify and discard any packets that traversed an excessive number of inter-satellite links and have thus become too old or have 'gone stale'.

In case of a system with multiple access up-links, in order to avoid congestion and possible poor performance (in terms of goodput) in the satellite network, input control may be performed by the entity responsible for allocating resources on the up-link so that the traffic entering the network remains at a reasonable level. The way input control is performed depends upon the system, the expected performances and the traffic matrices.

As mentioned above, the up-links may be operated in a time division multiple access (TDMA) manner to ensure fair allocation to users and to provide automatic control of throughput of traffic to the satellite nodes.

In some applications where each packet contains a class of service indicator, those packets having a high priority can be allocated preferentially to the first choice link, while those packets of lower priority can be allocated to second or third choice links unless there is significant capacity available on the first choice link.

It will be understood that the above description of a preferred embodiment is given by way of example only and that various modifications may be made by those skilled in the art without departing from the spirit and scope of the invention.

CLAIMS

1. A method of routing packet communications traffic in a communications network comprising a plurality of ground stations coupled by respective communications links to a constellation of satellite nodes interconnected by inter-satellite links, the method including providing each packet with a destination address, and, at each said satellite, reading the address of a said packet and, in response thereto, determining a first preferred link and a second auxiliary link for routing the packet, to a selected adjacent satellite via a said inter-satellite link or to a ground station with which the satellite is currently associated, and routing the packet, either via the first link when that that link is currently available, or via the second link when the first link is currently unavailable.

2. A method as claimed in claim 1, wherein the number of packets transmitted to the satellite network is limited at a level commensurate with minimising queuing of said packets within a said satellite node.

3. A connectionless satellite network comprising a constellation of satellite nodes each having on-board packet switching and routing functions based on deflection, the network providing ground communication via dedicated up-links each having an input control associated therewith so as to maintain the offered traffic at a level commensurate with minimising queuing of said packets within a said satellite node.

4. A communications network for carrying packet traffic in which each packet is provided with an address indicative of its destination, the network comprising a plurality of ground stations coupled by respective communications links to a constellation of satellite nodes interconnected by inter-satellite links, wherein each said satellite has means for reading the address of a said packet and, in response thereto, for determining a first preferred link and a second auxiliary link for routing the packet, to a selected

adjacent satellite via a said inter-satellite link or to a ground station with which the satellite is currently associated, and means for routing the packet, either via the first link when that that link is currently available, or via the second link when the first link is currently unavailable.

5. A method of routing packet communications traffic in a satellite communications system in which satellite nodes communicate with ground stations and are coupled via inter-satellite communications links, the method comprising:

providing each said packet with a destination address

determining from said address whether a communications packet received at a said satellite node has a local destination corresponding to a ground station currently in communication with the satellite, and routing that packet to the ground station in response to such a determination;

determining, when a communications packet has a non-local destination, a first preferred and a second less preferred inter-satellite link to an adjacent satellite; and

determining a criterion for routing a said non-local communications packet on either said first or said second inter-satellite link.

6. A method as claimed in claim 5, wherein said criterion is determined from the size of a queue of packets awaiting transmission on the said first or said second inter-satellite links.

7. A method as claimed in claim 6, wherein said criterion is determined from the number of inter-satellite links that have been traversed by the packet.

8. A method as claimed in claim 5, wherein said criterion is determined from priority information incorporated in the packet.

9. A method as claimed in claim 5, wherein the number of data packets transmitted to the satellite network is restricted so as to maintain acceptable performances.

10. A method as claimed in claim 5, wherein said packets comprise Internet protocol (IP) packets.

11. A method as claimed in claim 10, wherein a count is maintained of the number of inter-satellite links traversed by a said routed packet.

12. A method as claimed in claim 11, wherein a said packet is discarded after traversing a predetermined maximum number of inter-satellite links.

13. A method of routing packet communications traffic in a satellite communications system in which satellite nodes communicate with ground stations and are coupled via inter-satellite communications links, the method comprising:

transmitting packets from one or more said ground stations to a said satellite node;

determining at the satellite node for each said packet an inter-satellite link on which to transmit that packet to an adjacent satellite, the packets to be transmitted on each said inter-satellite link being placed in a;

determining the magnitude of said queue; and

restricting the rate at which packets are transmitted from the one or more ground stations when the queue magnitude exceeds a predetermined value.

14. A connectionless communications network for transporting packet communications traffic between user terminals, the network comprising;

a ground network portion consisting of a plurality of cells containing a plurality of said user terminals, each cell being serviced by a respective ground station; and

a satellite network portion consisting of a plurality of non-geostationary satellites, said satellites being interconnected by inter-satellite links so as to define a mesh network;

wherein, each said satellite has transceiver means for communicating selectively with said ground stations to transmit packets thereto and receive packets therefrom, and wherein each said satellite has address reading means for reading destination information contained in each said packet, and routing means responsive to the read address of the packet for directing that packet via a said inter-satellite link to an adjacent satellite or to a said ground station.

15. A network as claimed in claim 14, and incorporating means for restricting the number of packets transmitted to the satellite from a said ground station a level commensurate with minimising queuing of said packets within a said satellite node.

16. A communications satellite node for a connectionless communications packet network, the satellite node comprising transceiver means for communicating with a ground station to transmit packets thereto and to receive packets therefrom, address reading means for reading destination information contained in each said packet, and routing means responsive to the read address of the packet for directing that packet via an inter-satellite link to an adjacent similar satellite or to said ground station.

17. A communications satellite node for a network arranged to carry packet traffic in which each packet is provided with an address indicative of its destination, the satellite node having means for establishing a plurality of

communications links, means for reading the address of a said packet and, in response thereto, for determining a first preferred link and a second auxiliary link for routing the packet, and means for routing the packet, either via the first link when that that link is currently available, or via the second link when the first link is currently unavailable.

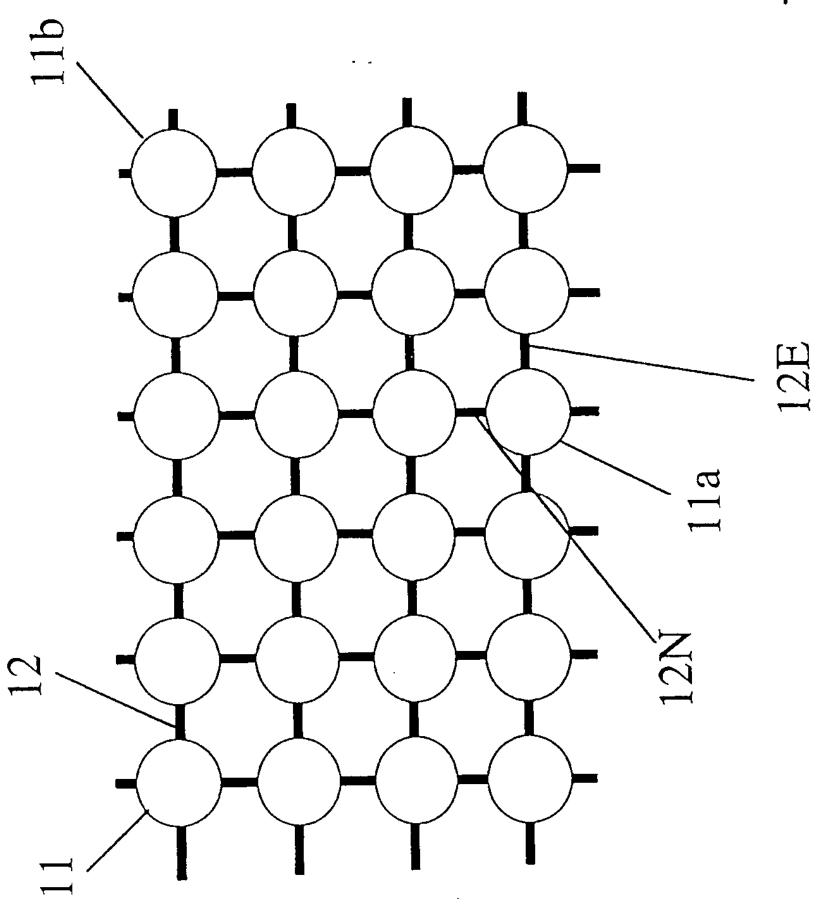

Fig.1

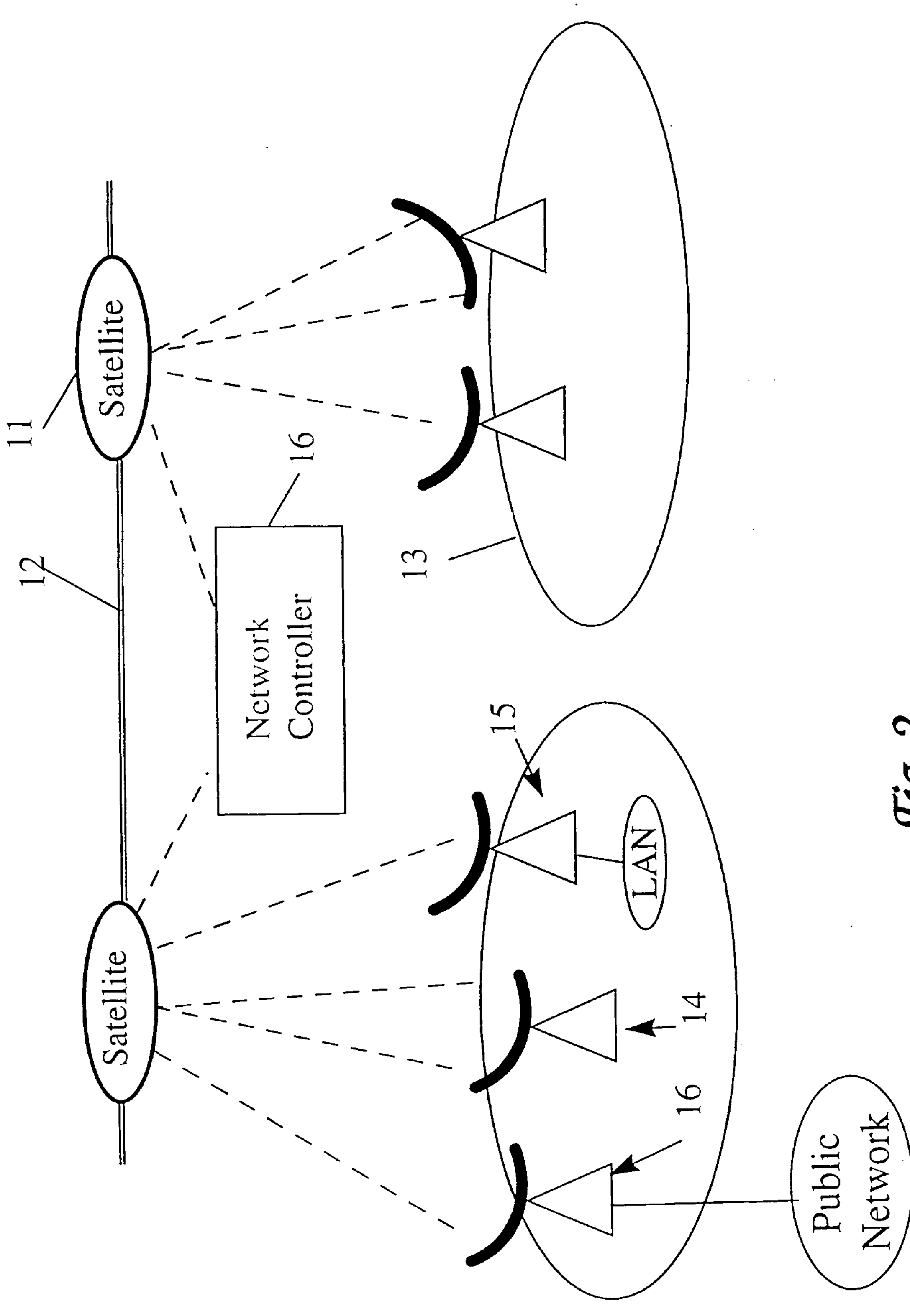
Satellite
11
12
Network Controller
16
13
Satellite
15
LAN
14
16
Public Network

Fig. 2

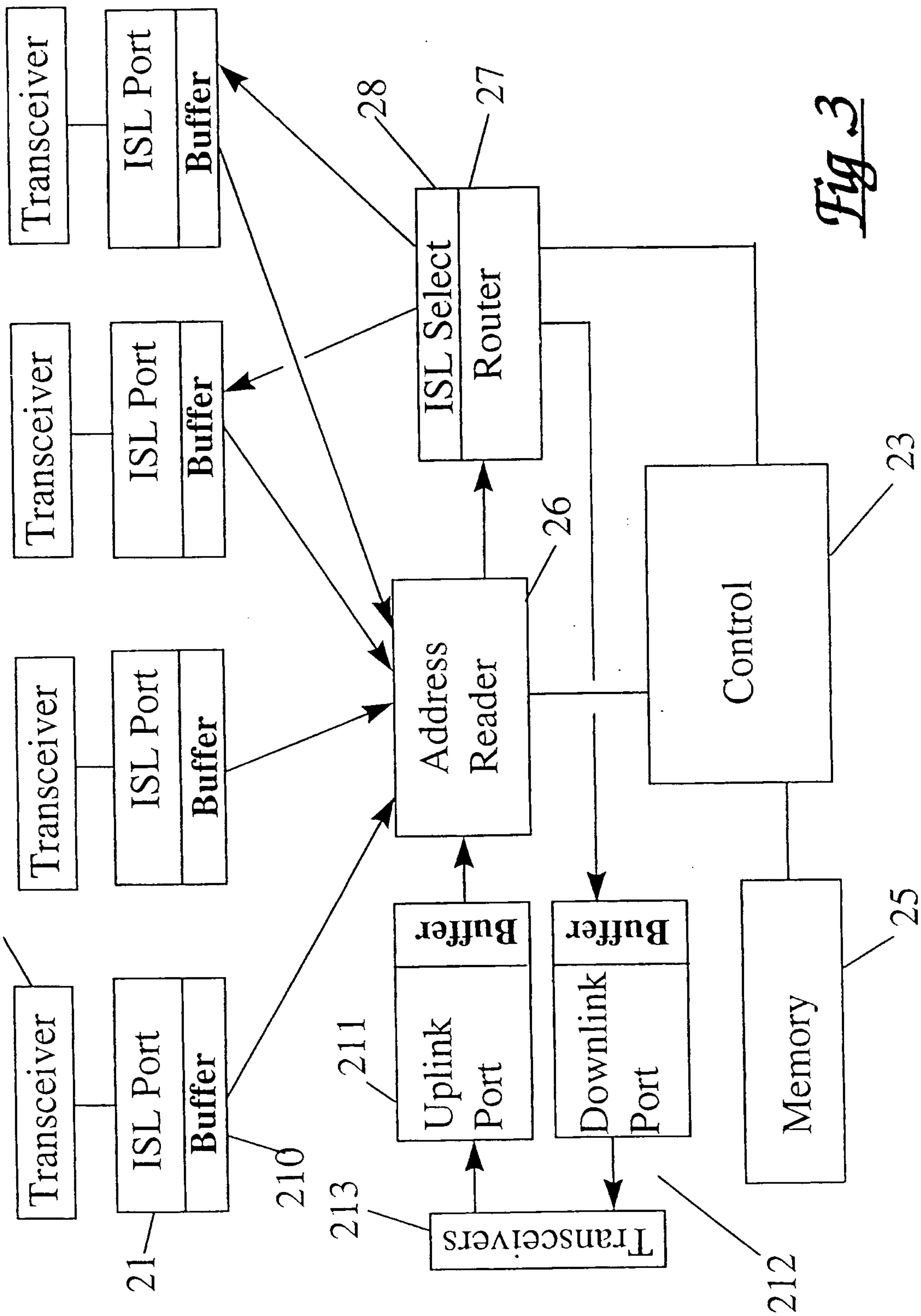
Transceiver
ISL Port
Buffer
Transceiver
ISL Port
Buffer
Transceiver
ISL Port
Buffer
Transceiver
ISL Port
Buffer
22
21
210
ISL Select
Router
28
27
Address
Reader
26
Control
23
Memory
25
Buffer
Uplink
Port
211
Buffer
Downlink
Port
212
Transceivers
213

Fig 3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/00324

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/185

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04L H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 467 345 A (CUTLER JR VICTOR H ET AL) 14 November 1995 see column 1, line 15 - column 2, line 60 see column 7, line 16 - line 17 see column 9, line 61 - column 10, line 20 see column 11, line 25 - line 34	1,4,5, 14,16,17
A		2,3, 6-13,15

-/--

[X] Further documents are listed in the continuation of box C

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 May 1999	02/06/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Larcinese, A

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 99/00324

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	FLAMINIO BORGONOVO ET AL: "DEFLECTION NETWORKS: ARCHITECTURES FOR METROPOLITAN AND WIDE AREA NETWORKS *" COMPUTER NETWORKS AND ISDN SYSTEMS, vol. 24, no. 2, 1 April 1992, pages 171-183, XP000257850 see page 171, left-hand column, line 1 - line 16 see page 174, left-hand column, line 8 - line 32 see page 175, right-hand column, line 1 - line 11	3
X	US 5 600 629 A (VAN DAELE GERRY ET AL) 4 February 1997 see column 1, line 59 - line 67 see column 3, line 45 - column 4, line 34 see column 5, line 27 - line 34 see column 5, line 65 - column 6, line 50	14,16
A		1-13,15, 17

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int tional Application No
PCT/GB 99/00324

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5467345 A	14-11-1995	FR 2720584 A	01-12-1995
US 5600629 A	04-02-1997	IT RM950496 A	25-01-1996